

REMARKS

Applicants respectfully request further examination and reconsideration in view of the above amendments and arguments set forth fully below. Claims 1-14 and 18-24 were previously pending in this instant application. Within the Office Action, Claims 1-14 and 18-24 have been rejected. By way of the above amendments Claims 1 and 10 have been amended and new Claim 25 has been added. Accordingly, Claims 1-14 and 18-25 are now pending in this application.

Rejections Under 35 U.S.C. § 112

Within the Office Action, Claims 1-14 and 18-24 have been rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention. Specifically, it is stated within the Office Action that Claims 1 and 10 recite the limitation of “the vaporizing occurring due to relatively low pressure with the reaction chamber” but continue to add the limitation of the “pressure range from about 70 to 130 torr” and “pressure range from about 10 to 130 torr,” respectively. It is stated within the Office Action that because one skilled in the art would consider ranges of 70 to 130 torr and 10 to 130 torr to be relatively high pressures, the two limitations recited appear to be inconsistent with each other.

By way of the above amendment, Claims 1 and 10 have been amended to delete the phrase “due to relatively low pressure within the reaction chamber.” Accordingly it is now clear that the liquid precursor vaporizes during entry into the reaction chamber due to the recited ranges of pressures. Accordingly, Applicant respectfully requests that the rejection of Claims 1-14 and 18-24 under 35 U.S.C. §112, second paragraph, be withdrawn.

Rejections Under 35 U.S.C. § 103(a)

Within the Office Action, Claims 1-14 and 18-24 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over the Japanese Publication No. 05-097583-A to Shinya (hereafter “Shinya”), in view of U.S. Patent No. 5,236,545 to Pryor (hereafter “Pryor”) and either U.S. Patent No. 5,451,260 to Versteeg et al. (hereafter “Versteeg”) or U.S. Patent No. 5,874,014 to Robson et al. (hereafter “Robson”). The Applicant respectfully traverses these rejections for the following reasons.

Diamond growth is a function of plasma density, reaction chamber pressure, carbon-to-oxygen ratio at the substrate surface, and precursor flow rate. The present invention provides a system for controlling all of these variables to promote rapid, substantially uniform and reproducible diamond growth. In accordance with the embodiments of the invention, the liquid precursor is continually supplied during the process without interruption. A dopant can be readily added to the liquid precursor, thus incorporating the dopant into the diamond structure formed. The method of the present invention allows diamond crystallites to be grown without seeding, provides a significant cost reduction over prior art methods and eliminates the need to use explosive gas mixtures or toxic precursors. As described below, there are several claimed features which provide the aforementioned advantages, which are neither taught nor suggested in the prior art.

The present invention is directed to a method of synthesizing diamond utilizing plasma-enhanced chemical vapor deposition (CVD) using a “non-magnetic-field microwave plasma system.” The present invention uses liquid precursors that are substantially free of water and that are formed from a mixture of methanol and at least one carbon and oxygen containing compound, such as ethanol, isopropanol, acetone or a mixture thereof. The carbon and oxygen containing compound has a carbon to oxygen ratio that is greater than one. The diamond growth process of the present invention is preferably carried out at relatively high pressures, such as in a range of 70 to 130 or 10 to 130 Torr. These and other distinguishing features are recited in each of the independent Claims 1 and 10.

Shinya discloses eliminating the need for hydrogen, having high explosion potential, for the purpose of increasing safety by using an OH group-containing alcohol as a reaction gas, and to synthesize a diamond film without diluting the gas with hydrogen. An OH group-containing alcohol (e.g. methanol or ethanol) is used as a reaction gas and is not diluted with hydrogen to form a diamond film. Shinya simply discloses a precursor containing methanol or ethanol. No mention is made in Shinya concerning the addition of the carbon and oxygen containing compound. Also, as acknowledged by the Examiner, Shinya does not disclose that the liquid precursor contains methanol and at least one carbon and oxygen containing compound having a carbon to oxygen ratio greater than one. Shinya also does not disclose the pressure range of about 70 to 130 Torr.

As described in a previous communication, Shinya fails to teach or suggest the use of a liquid precursor that is a liquid at the time that is introduced into the reaction chamber through the metering valve and vaporizes upon entry into the reaction chamber. Each of the independent Claims 1 and 10 has been amended to recite “wherein the liquid precursor enters the metering valve as liquid and vaporizes during entry into the reaction chamber” to further emphasize this disgusting feature. The Applicant also respectfully points out that Shinya fails to teach or suggest the use of a liquid precursor that is formed from a mixture of methanol and at least one carbon and oxygen containing compound, such as recited in each of the independent Claims 1 and an 10.

Pryor discloses a method of preparing heteroepitaxial diamond films on silicon substrates. In accordance with a method of Pryor, interface layers are first formed on suitable substrate. After the interface layers are formed, then heteroepitaxial diamond films are deposited on to the interface layers using CVD techniques. The CVD techniques of Pryor use reactive gas mixtures containing hydrogen, a carbon-containing gas or gases, and optionally, oxygen-containing gas or gases, which are introduced into a reaction chamber at low pressures.

Pryor clearly fails to teach or suggest any of the features recited in the independent Claims 1 and 10. Specifically, Pryor fails to teach or suggest the use of a liquid precursor without a gas stream, wherein the liquid precursor enters the metering valve as liquid and vaporizes upon entry into reaction chamber inlet at pressures in a range of 70 to 130 Torr, such as recited in the independent Claim 1, or upon entry into a reaction chamber at pressures in a range of 10 to 130 Torr, such as recited in the independent Claim 10.

Versteeg teaches a system that allows for delivering liquid precursor into a chemical vapor deposition reaction chamber. The solutions are injected through atomizing nozzles, which ensure that the liquid will be vaporized quicker in the reaction chamber. The liquid precursor can be injected in discrete, measured pulses through use of solenoid valves, or injected continuously.

However, Versteeg fails to teach or suggest a method for forming diamond that uses a liquid precursor, wherein the liquid precursor enters the metering valve as liquid and vaporizes during entry into a reaction chamber inlet or a reaction chamber. Nor does Versteeg teach or suggest that the liquid precursor is formed from a mixture of methanol and at least one carbon and oxygen containing compound that has carbon to oxygen ratio that is greater than one.

Robson discloses a method of introducing feed stock to the reaction chamber to form diamond. Robson teaches that suitable diamond-forming feedstock includes a mixture of alcohol and water. [Robson; Column 13, lines 18-21]

However, Robson clearly fails to teach or suggest the use of a liquid precursor that is substantially free of water and containing methanol and at least one carbon and oxygen containing compound having a carbon to oxygen ratio greater than one. Nor does Robson teach or suggest flowing a liquid precursor into the reaction chamber using the metering valve, in the absence of a gas stream, wherein the liquid precursor enters the metering valve as liquid and vaporizes during entry into the reaction chamber.

As mentioned above, Shinya simply discloses a precursor containing methanol or ethanol. No mention is made concerning the addition of the carbon and oxygen containing compound. Pryor lists off a number of combinations for the precursor solution, including a recommendation to include oxygen. However, all of Pryor's solutions contain hydrogen, the very reactive gas the present invention and Shinya's are designed to exclude from the process. The fact that Pryor includes hydrogen in all of his solutions while Shinya's purpose is to eliminate hydrogen shows there is no motivation to combine Shinya with Pryor for any purpose. And even if one were to combine Pryor and Shinya, the presence or absence of hydrogen, a central aspect on which both disagree, would render the combination impractical and unlikely.

In light of the arguments against combining Shinya and Pryor, it should also be noted that neither relates the significant benefits of using the present invention's precursor solution - which also proves that no evidence exists leading to a motivation to combine. In Paragraphs 0027-0033 of the present application, the Applicant discloses multiple benefits of using the solution. In Paragraph 0028, Lines 1-6, it is provided that "When the liquid precursor [is composed of the disclosed methanol-based solution], diamond growth is substantially uniform, reproducible, and at a higher growth rate than with conventional CVD methods." This is due to the unique deposition-aiding radicals that the methanol vapor releases when it disassociates. In Paragraph 0033 Lines 11-15, the Applicant notes that "...diamond crystallites could be grown on aluminum at temperatures below that of the melting point of aluminum...Also, diamond crystallites can be grown without seeding, which is difficult to do using other chemical vapor deposition systems."

With respect to the pressure ranges of 10 to 130 Torr and 70 to 130 Torr, these ranges are indeed novel and more importantly were not obvious prior to this invention due to the fact that

they are enabled by the recommended liquid precursor, the liquid precursor being substantially free of water and containing methanol and at least one carbon and oxygen containing compound having a carbon-to-oxygen ratio greater than one. Since the disclosed liquid precursor is novel and non-obvious, then the pressure range it affords are also nonobvious, especially when considering the fact that the ranges are larger and wider than any of the other ranges disclosed in the cited references.

For all of the reasons stated above, the Applicant contends that each of the independent Claims 1 and 10 is allowable over the teachings of Shinya alone or in combination with Prior and either Versteeg or Robson.


Claims 2-9 all depend on the independent Claim 10 and Claims 11-14 and 18-25 all depend on the independent Claim 10. As described above, the independent Claims 1 and 10 are both allowable over the teachings of Shinya alone or in combination with Pryor and either Versteeg or Robson. Accordingly, Claims 2-9, 11-14 and 18-24 are also all allowable as being dependent on allowable base claims.

The new dependent Claim 25 recites wherein flowing the liquid precursor into the reaction chamber is controlled by monitoring the metering valve and adjusting a flow of the liquid precursor to maintain a substantially constant temperature. These features find support in the originally filed Specification [Specification; page 9, lines 11-18] and are similar to features recited in the dependent Claim 23. No new subject matter has been added by way of this amendment.

For the reasons given above, Applicants respectfully submit that Claims 1-14 and 18-25 are now in a condition for allowance, and allowance at an early date would be appreciated. Should the Examiner have any questions or comments, the Examiner is encouraged to call the undersigned at (408) 530-9700 to discuss the same so that any outstanding issues can be expeditiously resolved.

Respectfully submitted,
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Dated: May 11, 2007

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